

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau(43) International Publication Date  
18 April 2002 (18.04.2002)

PCT

(10) International Publication Number  
WO 02/30591 A1(51) International Patent Classification<sup>7</sup>: B21D 53/08

(21) International Application Number: PCT/IB01/01859

(22) International Filing Date: 8 October 2001 (08.10.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
0024625.6 7 October 2000 (07.10.2000) GB

(71) Applicant (for all designated States except US): APPLIED SYSTEMS MANAGEMENT LIMITED, [GB/GB]; Queens House, Queens Road, Coventry CV1 3DR (GB).

(72) Inventor; and

(75) Inventor/Applicant (for US only): PIERCE, David, Bland [GB/GB]; 24 Dorsington Close, Hatton Park, Warwick CV35 7TH (GB).

(74) Agent: GEE, Steven, William; D.W. &amp; S.W. Gee, 1 South Lynn Gardens, London Road, Shipston on Stour CV36 4ER (GB).

(81) Designated States (national): AE, AG, AI, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

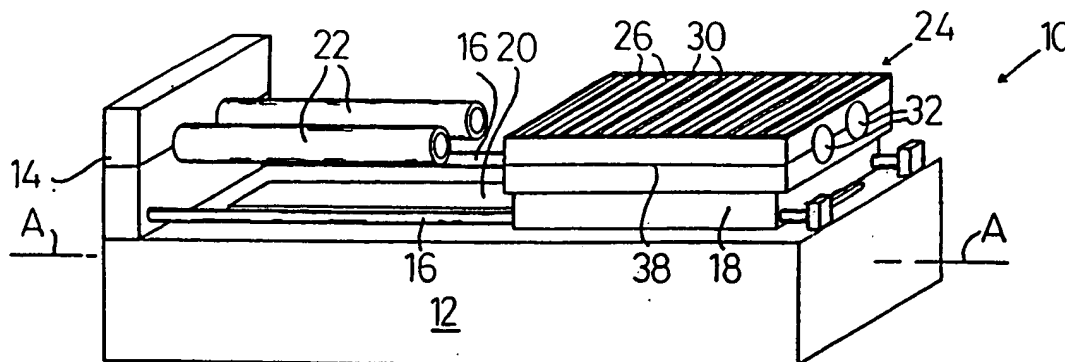
(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: TUBE FINNING MACHINE AND METHOD OF USE



(57) Abstract: This invention relates to a tube finning machine (10), and in particular to a machine capable of fitting several fins (26) to one or more tubes (26) at the same time, the assembled finned tube being suitable for heat exchange applications. According to one aspect of the invention there is provided a tube finning machine for mounting extended surface members (96) upon one or more tubes, the machine having a base (10), carrier means movable relative to the base, drive means (20) for moving the carrier means (18) in a longitudinal direction, and cartridge means (24) for locating a plurality of extended surface members (26), the cartridge means having respective support means (30) for each extended surface member, and at least some of the support means being movable



VO 02/30591 A1

- 1 -

## TUBE FINNING MACHINE AND METHOD OF USE

## FIELD OF THE INVENTION

5 This invention relates to a tube finning machine and method of use, and in particular to a machine capable of fitting several extended surface members (or fins) to one or more tubes at the same time, the assembled finned tube being suitable for heat exchange applications. In one aspect, the  
10 present invention is an improvement to a machine such as that disclosed in patent application WO96/35093.

## BACKGROUND TO THE INVENTION

15 Often it is necessary to cool a working fluid, and it is known for this purpose to use a heat exchanger. Heat exchangers often comprise one or more metallic tubes suspended between two tube plates. The working fluid to be  
20 cooled, which may for example be water or oil, flows through the tubes, whilst the coolant passes around and between those tubes, the working fluid giving up its latent heat to the tubes and thus to the coolant.

25 The effective surface area of a tube can be enlarged in order to increase the heat transfer, as by the addition of one or more annular extended surface members or fins in thermal contact with the outer surface of the tube. Such finned tubes are particularly useful if the coolant has a  
30 low viscosity, and if the coolant is a gas, such as air.

If the tubes are to withstand the internal pressure of the fluid to be cooled, the addition of the fins should not reduce or significantly reduce the tube bursting strength.  
35 If the fins are to increase the heat transfer they should not significantly inhibit the flow of coolant, and preferably should encourage turbulent coolant flow.

- 2 -

The tubes to be used for heat exchangers should meet certain standards (in the UK for instance British Standard 2871 Part 3), these standards being relevant also for those tubes which are formed by extrusion to provide selected internal  
5 formations chosen to enhance internal turbulent flow i.e. to avoid laminar or stratified flow of the working fluid to be cooled; desirably the tube finning should not reduce those respective standards e.g. of tube wall thickness and thus of strength, or of tube uniformity and fin engagement and thus  
10 of heat transfer to the fins.

The fins should be positioned on the tube so as to encourage maximum heat transfer to the coolant, which will not occur if the fin spacing is irregular, or if the fin angles are  
15 irregular (with an annular gap of varying axial length between adjacent fins).

If the tube walls need to be thinned to accept the fins, one or more of the tubes may burst in service and need to be  
20 plugged; if the fins are irregularly spaced and/or angled the performance of the heat exchanger will be reduced.

It is a known design criterion when constructing a matrix or array of finned tubes for a heat exchanger both to arrange  
25 the tubes as close to each other as possible (to reduce the size of the heat exchanger), and to have a maximum area available for thermal transfer between the working fluid and the coolant (to maximise the possible heat exchange). When utilising tubes fitted with the known annular fins in such  
30 an array, the spacing between the tubes will be limited by the outer diameter of the fin(s); if as is usual the fins have circular outer peripheries there are areas between adjacent tubes which do not contribute to heat transfer, and a finning method and machine permitting fins to be fitted  
35 which can utilise these areas is desirable.

The performance of a heat exchanger in part depends upon the

- 3 -

fins i.e. to the aggregate extended area available for heat exchange, as well as to the positioning and disposition of those fins.

5 When seeking to overcome the disadvantage of the unused heat-exchange area caused by the use of fins with a circular periphery, it is known to replace the separate fins of adjacent tubes by axially-spaced "common-fins" i.e. fins which engage (and interconnect) several tubes. Typically, a  
10 common-fin takes the form of an extended plate having several apertures, each aperture being adapted to receive a respective tube, the plate-like common-fin being in simultaneous thermal contact with several tubes, and being adapted to transfer the heat from all of the tubes across  
15 the full area therebetween. An array of tubes to which are mounted a plurality of multi-apertured common-fins is referred to herein as a "fin block", though in other documents it is also referred to as a "coil block" or "block fin".

20

It will be understood that in a fin block, each fin can be continuous between and around each tube in the block, so that a minimum of heat transfer area is wasted. It will be further understood that the tubes in each block are fixed  
25 relative to the other tubes of that block by the prefitted plate-like common-fins.

A known further advantage of such assembled fin block is its relative ease of fitment into a heat exchanger. Thus, for a  
30 heat exchanger requiring two hundred separate finned tubes for instance, each of the two hundred tubes must be fitted to both tube plates, and perhaps also to separate support plates as may be required for longer tubes. However, if a fin block is prepared having twenty tubes, then only ten  
35 such blocks are required to be handled and fitted.

In a known method of manufacturing a fin block, a stack of

- 4 -

by a distance to suit the requirements of a particular heat exchanger; each common-fin has several apertures, the apertures corresponding in pattern to the required tube arrangement. The apertures are slightly larger than the  
5 outside diameter of the tubes, and the common-fins are held with their respective apertures aligned. The tubes are then individually passed through the apertures, and when in position a "bullet" is pulled through each tube, to expand the tube wall into mechanical contact with the respective  
10 fin apertures. A method of this general type is disclosed in US patent 3,889,745.

This method is not suitable for extruded tubes having internal formations (e.g. for promoting turbulent flow of  
15 the liquid to be cooled), since a bullet cannot be passed through such tubes.

Another disadvantage of this known bulleting method is that the wall thickness of the tubes is limited by the need for  
20 the wall to be stretched by the bulleting operation, so that thinner-walled tubes have to be used than might otherwise be desired; for example, in practice for a stainless steel tube with an outer diameter of 0.75" (19.05mm) it is rare for tube thicker than 22 Gauge ("Standard Wire Gauge") to be  
25 bulletted. A further disadvantage is that the bulleting operation introduces stress into the tubes, and can change the grain structure; the stress is typically not removed by heat treatment since the heat treatment would act also to soften the fins and reduce the thermal contact between the  
30 fins and tubes, i.e. the stress induced by the bulleting operation typically remains in the tube and thus in the heat exchanger as an unwanted side effect of this method of production. Yet another disadvantage is that the material specification of the tubes can be altered by the bulleting  
35 operation; for example, if the heat exchanger user specified that annealed tubes should be used, the bulleting operation can in some circumstances alter the annealed material into a

- 5 -

is that the tube must be of deformable material, so limiting the material which can be used.

Bulleting can also result in non-parallel finning. As the  
5 bullet is pulled through the tube, the tube wall can form an  
angled "front" which moves down the tube immediately ahead  
of the bullet, as a "ripple"; adjacent fins subject to the  
"ripple" are likely either to be moved along the tube, or to  
adopt different angles relative to the tube, resulting on  
10 occasion with parts of adjacent fins touching and with other  
parts spaced by a greater distance than intended. The  
expansion caused by the bullet is such that once the bullet  
has passed a fin, the position of the fin cannot  
subsequently be corrected or altered.

15 Usually when "rippling" is seen to be occurring during tube  
finning the bullet has nevertheless to be fully drawn  
through the tube so that it can be reused, even though the  
manufacturer recognises that the resulting finned tube is  
20 likely to be rejected as unsuitable for heat exchanger use.  
Also, if a set of tubes is finned whilst in position in a  
heat exchanger array, any fin displacement which occurs upon  
internal and thus non-visible tubes cannot be observed, so  
that the resulting loss of heat exchanger performance might  
25 not be realised until the exchanger is in service.

US patent 3,733,673 discloses a machine for fitting several  
fins to one or two tubes at the same time. The fins are  
arranged in a cartridge, and held along their top and bottom  
30 edges. Each fin has a number of apertures therein which are  
sized and shaped to correspond closely with the outer  
periphery of the tubes to be fitted thereinto. The machine  
is pneumatically actuated and can drive one or two tubes at  
a time through the aligned apertures in the fins. Following  
35 insertion of the fin or fins, the machine can subsequently  
be used to insert one or two further tubes into respective  
apertures of the fins, until all of the tubes have been

- 6 -

It is a disadvantage of this machine that the cartridge provides only limited support for the fins, and so the fins need to be sufficiently rigid to remain undeformed by the insertion of the tubes. On the other hand, it is desirable that there be sufficient engagement between the tubes and the fins to ensure good heat transfer therebetween, and it is also desirable that the fins be as thin as possible to reduce the weight of the assembled fin block and also to maximise heat transfer. A compromise is therefore necessary between reducing the thickness of the fins so as to maximise heat exchange, and increasing the thickness of the fins so as to ensure that the fins do not become deformed as the tubes are forced therethrough. A further compromise is necessary between arranging the fins to be a tight fit upon the tubes (so as to maximise the heat transfer therebetween), and arranging the fins to be a loose fit upon the tubes so that the tubes can be moved more easily therethrough with a reduced likelihood of deformation of the fins.

It is another disadvantage of this machine that only two tubes can be inserted into the fins at a time, so that considerable time is taken to produce a large fin block. The provision of a maximum of two tubes is due to some extent to the maximum power of the machine, but greater relevance is understood to be given to the practical disadvantage that as more tubes are inserted at the same time, the greater is the likelihood of deforming some of the fins.

A machine for making fin block (though it could also apply individual fins to individual tubes) is disclosed in WO96/35093. That machine utilises a linear motor to drive a fin (or common-fin) onto one or more tubes. In an alternative method of using the machine, a first fin can be driven onto the end of the tubes, and a second fin driven

- 7 -

driven along the tubes to their predetermined positions. It is accepted that the collars of the two fins will interlock in such circumstances, and it is necessary that the machine have sufficient power to drive such interlocked fins.

5

#### SUMMARY OF THE INVENTION

The present invention seeks to improve upon the prior art machines described above, and seeks to reduce or avoid the disadvantages associated therewith.

According to a first aspect of the invention there is provided a tube finning machine for mounting extended surface members or fins upon one or more tubes, the machine having a base, carrier means movable relative to the base, drive means for moving the carrier means in a longitudinal direction, and cartridge means for locating a plurality of extended surface members, the cartridge means having respective support means for each extended surface member, and at least some of the support means being movable relative to the cartridge.

The machine according to the third aspect differs from that of U.S. patent 3,733,673 in that the fins are able to "nest" together upon the tube. Thus, it is known for the fins to have collars surrounding the tube-receiving apertures, one purpose of the collars being to increase the area of contact between the tube and the fin. However, in many applications it is desired that the fins are sufficiently closely spaced for the collar of one fin to engage the collar of the adjacent fin. If the fins are pressed together the collars can interlock, serving to further secure the fins in position upon the tube. However, when the fins are to be moved relative to the tube(s) during the finning procedure, it is not desired that the collars interlock since this increases the frictional resistance to movement, and so the



- 8 -

machine according to the first aspect each fin can be moved to a predetermined position upon the tube(s), whether or not the fins have collars, and whether or not those collars are desired to interlock.

5

According to a second aspect of the invention there is provided a tube finning machine for mounting extended surface members upon one or more tubes, the machine having a base, carrier means movable relative to the base, drive  
10 means for moving the carrier means, and cartridge means for locating a plurality of extended surface members, the cartridge means having a respective support means for each extended surface member, each support means spanning a substantial part of the extended surface member.

15

The machine according to the second aspect differs from that of U.S. patent 3,733,673 in that a greater area of the fins are supported by the cartridge means, reducing the likelihood of the fins becoming damaged or distorted during  
20 tube finning. Alternatively stated, the fins may be made thinner, and their engagement with the tube(s) increased, so as to enhance the heat transfer, with less risk of distortion.

25 According to a third aspect of the invention there is provided a tube finning machine for the manufacture of a heat exchange fin block, which machine includes a base, carrier means movable relative to the base, drive means for moving the carrier means, and cartridge means for locating a  
30 number of fins, a clamping means mounted to the base for clamping a portion of at least one tube in a substantially fixed position relative to the base, the cartridge means being connected to the carrier means so that the number of fins can be moved to an axially predetermined position  
35 relative to the tube(s).

The machine according to the third aspect differs from that

- 9 -

to the substantially stationary tube(s). This has a significant advantage when the machine is used to assemble larger fin blocks. Thus, it will be understood that whilst a number of fins can be driven along the tube(s) by the present machine (and one or two tubes can be driven through a number of fins by the prior art machine), the power of the machine determines the maximum number of fins which can be used at any one time, i.e. the machine must be able to exceed the combined frictional resistance of the fins and tube(s). If a fin block has two tubes and one thousand common-fins, for example, it is not likely to be practical to build a machine having sufficient power to fit all of those fins at one time, and instead it would be practical to fit a smaller number of common-fins (or a "set" of common-fins) at one time, for example twenty common fins, and successively to fit fifty such sets. With a machine in which the tubes move, there would need to be a means of supporting the previously-fitted fins as they are moved with the tubes, and the means to move the tubes would need to be robust enough to withstand and move the weight of the tubes plus an increasing number of fins. With a machine according to the present invention, however, the tubes and the previously-fitted fins are stationary, and can more readily be supported; the movable carrier means need only support and move a cartridge of known and consistent weight. Clearly also, the likelihood of damage to the previously-fitted fins is much reduced if they remain stationary during the remainder of the finning procedure, or alternatively stated less precautions need to be taken to prevent damage to the stationary fins.

The disadvantage of the prior art machine is more manifest if the number of tubes in the assembled fin block is greater than two, since in such circumstances it is not feasible to assemble "sets" of fins as above described to two tubes and subsequently to another two tubes. The heat exchanger assembler would have to construct such a fin block as

- 10 -

separate smaller fin blocks, so avoiding the advantage of a single larger fin block.

Preferably, the periphery of the fins lies within the  
5 periphery of the support means, so that the support means  
can provide support to substantially the whole of the fin.  
However, in such embodiments it is necessary that the  
support means be apertured to allow the tube(s) to pass  
therethrough; it is desirable that the support means do not  
10 engage the tube(s) whereas it is desirable that the fins do  
engage the tube(s).

Preferably, at least some of the support means are  
longitudinally movable relative to the cartridge means.  
15 Such an arrangement allows the support means to adopt  
relatively widely-spaced positions during loading of the  
fins into the cartridge, and closely-spaced positions during  
fitment of the fins onto the tube(s). The closely-spaced  
positions may correspond to the desired spacing between the  
20 fins upon the tube.

Desirably, the support means are biased apart by resilient  
biasing means. Such an arrangement results in the support  
means automatically adopting their widely-spaced positions  
25 prior to loading of the fins into the cartridge. The  
support means can be forced into their closely-spaced  
positions (perhaps by the carrier means) during the finning  
process.

30 In embodiments in which the support means have apertures  
through which the tube(s) can pass, the support means are  
preferably formed in separable parts so that they can be  
separated from the fins following fitment of the fins onto  
the tubes. In any event, the cartridge (and the support  
35 means carried thereby) must be able to move laterally  
relative to the longitudinal axis of the tubes after fitment  
of the fins, since the presence of the fins will prevent

- 11 -

cartridge is separable from the finned tube(s) whilst the tube(s) remains clamped by the clamping means, e.g. so that the cartridge can be re-filled with fins for subsequent location onto the tube(s). Alternatively, the tube(s) must  
5 be removed from the clamping means before the cartridge can be separated from the finned tube, it being arranged that successive cartridges can be used if a large number of fins is to be fitted to the tube(s).

10 Desirably, in embodiments having movable support means, the support means carry spacing means. The purpose of the spacing means is to define the minimum separation between adjacent support means, and may be desired in applications utilising fins with collars. Thus, the spacing means can if  
15 desired ensure that the support means (and therefore the fitted fins) are spaced apart by a distance greater than the length of the collars, so that the support means can be removed from between the fitted fins without fouling the collars. Alternative arrangements are possible in which the  
20 collars project into the plane of the support means during fin fitment, but in those embodiments it is desired that the spacing means and support means together ensure that the collar of one fin does not become interlocked with the collar of an adjacent fin.

25

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example, with  
30 reference to the accompanying schematic drawings, in which:

Fig.1 shows a tube finning machine according to the invention, prior to fitment of several common-fins to two tubes;

35

Fig.2 shows a plan view, partly in section, of a cartridge means similar to that of the machine of Fig. 1.

- 12 -

- Fig.3 shows a view similar to Fig.2 of an alternative cartridge means prior to loading of the fins;
- 5 Fig.4 shows the cartridge of Fig.3 during tube finning;
- Fig.5 shows a sectional view along the line V-V of Fig.4;
- 10 Fig.6 shows a sectional view along the line VI-VI of Fig.4;
- Fig.7 shows a view of a wall member of another alternative cartridge means;
- 15 Fig.8 shows a carousel arrangement for the clamping means; and
- Fig.9 shows a side view of part of yet another alternative cartridge means.
- 20

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

- 25 In this description, directional terms such as "top", "bottom", "upper", "lower" etc. refer to the orientation of the machine and its components as drawn in Fig.1, which is foreseen to be the normal orientation of use. However, the use of a machine at other orientations (e.g. with the tubes
- 30 standing, or suspended, substantially vertically) is not excluded, and the relative directional terms can be translated to such orientation.

In this embodiment the machine 10 comprises a substantially

35 rigid base 12, at one end of which is a fixedly mounted clamping means 14. The base has a pair of guide bars 16, upon which can slide carrier means 18. The drive means for

- 13 -

motor of known design which includes a first winding 20 mounted upon the base 12 and arranged substantially parallel to the longitudinal axis A-A of the base 12, and a second winding (not seen) located within the carrier means 18; the  
5 second winding slides with the carrier means 18 closely adjacent the first winding 20. The electrical wires leading to the first and second windings are of known form, and are not shown.

10 In alternative embodiments other drive means could be employed, such as hydraulic, pneumatic, or screw drive, as might be desired in the particular application.

In this embodiment, the clamping means 14 is adapted to  
15 secure the ends of two tubes 22 so that the tubes are held substantially rigidly relative to the base 12. The clamping of the ends of the tubes can be by any suitable means (several of which are described in WO96/35093 for example).

20 Located upon the carrier means is a cartridge means 24, into which have been loaded several extended surface members or fins 26. In this embodiment there are nine fins 26, adjacent fins being separated by respective support means or wall members 30 (see also the wall members 130 of Fig.2).  
25 The end walls of the cartridge means 24 have openings 32 therethrough, and the wall members 30 have similar openings, so that the tubes 22 can pass therethrough, preferably without contacting the periphery of the openings.

30 As better seen in Fig.2, the fins 26,126 in the embodiments described herein are common-fins, i.e. each fin 26,126 has two apertures 34, so that each can be connected to both of the tubes 22. It is expected that the present invention will almost invariably utilise common-fins, though it could  
35 clearly be used to apply separate, individual, fins to one or more tubes at the same time, depending upon the application for which the finned tube is intended.

- 14 -

The walls 30,130 are an integral part of the cartridge means 24,124, and in the embodiments of Figs. 1 and 2 are immovable relative to the remainder of the cartridge means. The separation S between the adjacent wall members  
5 determines the separation between the fins in the assembled fin block. Thus, it will be understood that when the cartridge means is moved towards and around the tubes 22, the tubes 22 engage the collars 36 of the fins 126. It is desired that the collars 36 face in the direction of  
10 relative movement of the tubes, i.e. in the embodiment of Fig.2 the collars are directed towards the right and the tubes will move relatively towards the right as the fins are inserted thereonto. Since the collars 36 are designed to be a frictional fit around the tubes 22, the tubes will act to  
15 push each fin towards the right until it engages its adjacent wall member 130. It will be noted that during fitment of the fins 126 they are substantially fully supported by the respective wall members 130, so that they are not likely to deform even if they are relatively thin,  
20 and/or the friction between the tube and collar is considerable.

It will be recognised that when the fins have been fitted onto the tubes, it is not possible to withdraw the cartridge  
25 means 24,124 longitudinally relative to the tubes, i.e. in the direction along the axis A-A. It is therefore necessary that the cartridge means 24,124 be removed laterally, and for this purpose the cartridge means 24,124 is split longitudinally substantially along its mid-line 38 (Fig.1),  
30 permitting the top half to be removed upwardly and the bottom half to be removed downwardly.

In the embodiment of Figs.3 and 4, the wall members 230 are movably mounted within the cartridge means 224, and are  
35 biased apart by respective compression springs 40. Mounted to the cartridge 224 are guide bars 42. The wall members 230 are slidably mounted upon the guide bars 42, and

- 15 -

The wall members 230 each carry spacers 44, which serve to determine the minimum separation between the wall members 230, and thus to determine the separation  $s$  between the fitted fins (Fig.4).

5

Fig.3 shows the cartridge means 224 prior to loading of the fins. Fig.4 shows the cartridge means 234 following loading of the fins 226 and during fitment onto the tubes 22. It will be noted that the cartridge includes an opening 46  
10 which can accommodate an abutment 50 of the carrier means, i.e. following loading of the fins 226 the abutment 50 can be moved from a position shown in dotted outline to a position shown in solid outline, during which movement the springs 40 are compressed and the separation between  
15 adjacent fins 226 is reduced to the desired fin spacing  $s$ .

The point at which the compression of the springs 40 occurs will depend upon the rating of those springs and the resistance to movement of the fins 226 along the tubes 22.  
20 Thus, the drive means acts through the abutment 50 directly upon (and in this embodiment only upon) the wall member 230a, and that wall member 230a will drive the whole of the cartridge 224 until the frictional resistance to such movement (perhaps caused by the leading fin or fins 226  
25 engaging the tubes 22) exceeds the rating of the springs 40, whereupon the springs 40 will successively be compressed. It is of course necessary to arrange that the combined spring rating is lower than the overall power of the machine, so that all of the springs are fully compressed  
30 when the lead fin has been pushed to its predetermined position upon the tubes, ensuring that all of the other fins are similarly positioned in their predetermined positions. The rating of the springs 40 will typically be small, since they are only required to force the wall members 230 apart  
35 to permit ease of loading of the fins.

It will be noted that in the embodiment of Figs. 3 and 4 the



- 16 -

respective wall members. The effect of this is that the collars 36 of the fins are maintained away from the openings 52 of the wall members 230. However, it also results in less than complete support for the fins during fitment onto the tubes. It might be desired to increase the area of the spacers to increase the support for the fins. In alternative embodiments, however, the spacers can project towards the right (as drawn) from the respective wall members, so that during fitment the fins are substantially fully supported by the respective wall members. In yet further alternative embodiments, the spacers are omitted, and the fitted fins are separated by a spacing corresponding to the thickness of the wall members 230. Such spacing could be close to the dimension of the collar, but it is desirable in certain embodiments that the cartridge means separate the fins by a sufficient distance to prevent interlocking of adjacent collars, which interlocking significantly increases the frictional resistance to movement of the fins along the tubes.

As seen in Figs. 5 and 6, the cartridge means 224 is mounted to slide along the base, specifically along guides 52 which lie parallel to the longitudinal axis A-A. The carrier means 18 is also mounted to slide along the base, specifically along guides 54. Clearly, the form of the guides 52, 54 can be chosen as desired, and the form of the guides for the cartridge means 224 might be substantially identical to the form of the guides for the carrier means 18, for example. In the embodiment shown the cartridge means 224 may simply be placed into the guides 52, but in alternative embodiments the cartridge means might be more securely fastened to the base, e.g. it might be securable to guide members permanently (but slidably) mounted to the base.

35

The embodiment of Figs. 3-6 has a split 238 along its mid-line, so that the top "half" of the cartridge means can be

- 17 -

the bottom "half" can be moved downwardly. The two "halves" can be secured together by any suitable releasable fastening means. Since the split 238 also necessarily crosses the wall members 230, four guide bars 42 are provided, one to  
5 either side of the wall members 230 above and below the split 238.

In the alternative embodiment of Fig.7, the cartridge means 324 is not split but instead is designed to be removable as  
10 a single component upwardly following fitment of the fins upon the tubes. Thus, the end walls of the cartridge means (not shown) and the wall members 330, all incorporate open-sided apertures 60, the apertures allowing passage of the tubes 22 therethrough, but also subsequently allowing  
15 separation of the cartridge means from the finned tube. It will be noted that there must be provision for preventing the fins from falling out of the cartridge following loading thereinto, and in this embodiment this is provided for in that the cartridge lies directly upon the carrier means 18,  
20 and the fins are loaded into the cartridge after the cartridge has been placed upon the carrier means 18. In alternative embodiments in which it is desired that the cartridge be loaded away from the machine (so as to reduce the "down-time" of the machine) other suitable means for  
25 preventing the fins from falling out of the cartridge can be provided, which means can be removed once the cartridge is mounted upon the machine and the fins are supported by the carrier means (or are supported by the tubes during finning). In another embodiment, the ledges 62 which are  
30 secured to the side walls 64 of the cartridge means 324 can include movable projections which can support the fins as these are loaded thereinto and during fitment onto the tubes 22, but which can be moved to allow the cartridge means 324 to be separated from the finned tubes.

35

In the embodiment of Fig.7 the wall members 330 are movable, and the cartridge means has two guide bars 342 upon which

- 18 -

embodiment of Figs. 3-6. In an alternative embodiment the wall members can be secured in fixed positions relative to the side walls.

5 Fig.8 shows a carousel clamping means 66 for the ends of the tubes. In this embodiment, the tube 68 is bent into a "U" shape, which is not uncommon in heat exchanger applications. The base of the "U" is clamped between the jaw 70 and the housing 72 (which clamping might be effected by hydraulic or  
10 pneumatic pressure, for example, or by a nut and bolt, as desired). Only one U-shaped tube 68 is shown, though in practice up to six tubes 68 could be secured to the carousel, so that in use one U-shaped tube could be facing the carrier means in the finning position, whilst other  
15 tubes could be in position to be removed from the carousel following finning, and further tubes could be in position, or prepared to be located in position, ready for finning.

The carousel arrangement can increase the utility of the  
20 machine by reducing the down-time associated with clamping the tube(s) into position prior to finning, and subsequently removing the finned tubes.

In the embodiment of Fig.9, the wall members 430 are placed  
25 at fixed longitudinal positions in the cartridge means (i.e. they are not able to move together and apart as in the embodiments of Figs. 3-7. The wall members are each split at their mid-line 438, so that the top part of the wall member can be moved upwards to separate it from a fitted  
30 fin, whilst the bottom part can be moved downwards to separate it from the fitted fin. In this embodiment, however, the parts of each wall member 430 can be moved independently of the other wall members and the remainder of the cartridge, and in Fig.9 the parts of the leading wall  
35 member 430a have been moved to separate them from the leading fin 426a.

- 20 -

of all of the wall members (so that all of the fins which were loaded into the cartridge means have been fitted in their predetermined positions upon the tube(s)), the cartridge means can be withdrawn longitudinally relative to the tube(s) 422, the parts of the wall members 430 being brought together once again when the cartridge means has cleared the end of the tube(s).

In the embodiments described the tube(s) are (substantially) fixed relative to the base of the machine and the fins are movable relative thereto; this arrangement has considerable advantages as outlined above. Nevertheless, arrangements in which the fins are substantially fixed relative to the base and the tubes are movable relative to the base, and in which both the fins and the tubes are movable relative to the base, and not necessarily excluded from the scope of the invention.

- 19 -

Following the separation of the wall member 430a, the cartridge can be moved farther to the left as drawn, the wall member 430b driving the next fin 426b to the left, and into engagement with the collar 436 of the fin 426a (if  
5 desired the engagement can be such as to interlock the two fins 426a,b together so obtaining the benefits of such interlocking).

When the fin 426b has been moved into engagement with the  
10 fin 426a, the wall member 430b can be separated, exposing the next fin which can be subsequently moved into engagement with the collar of fin 426b, and so on.

It can be arranged that the cartridge means of this  
15 embodiment does not have a leading end wall to the left of the leading fin 426a, so that the leading fin can be moved into engagement with the collar of an existing fin, i.e. a fin which has previously been positioned upon the tube 422, perhaps by the movement of a previous cartridge means.

20

In Fig.9, the fin 426b is shown at a slight distance away from the wall member 430b, but this is for reasons of clarity only. Thus, in practice the wall member 430b will drive the fin 426b towards the left as the cartridge is  
25 itself driven to the left by the carrier means, and so each fin member will engage its respective wall member.

It will be appreciated that the fin members 426 could be spaced apart within the cartridge means of Fig.9 by any  
30 desired distance, and the wall members 430 could be as thick as required to ensure that neither they nor the fins will become deformed during fitment onto the tube(s).

The separation of the parts of the wall members can be  
35 effected by any suitable means, such as for example pneumatic actuators. The parts of the wall members 430 can be arranged to slide within linear guides located in the side walls of the cartridge means. Following the separation

## CLAIMS

1. A tube finning machine for mounting extended surface members upon one or more tubes, the machine having a base, carrier means movable relative to the base, drive means for moving the carrier means in a longitudinal direction, and cartridge means for locating a plurality of extended surface members, characterised in that the cartridge means has respective support means for each extended surface member, and in that at least some of the support means are movable relative to the cartridge.
2. A tube finning machine according to claim 1 in which the support means are movable laterally relative to the longitudinal direction.
3. A tube finning machine according to claim 1 in which each support means spans a substantial part of the extended surface member.
4. A tube finning machine according to claim 3 in which the periphery of the extended surface members lie within the periphery of the support means.
5. A tube finning machine according to claim 1 in which the support means are biased apart by resilient biasing means.
6. A tube finning machine according to claim 1 in which each support means comprises separable parts.
7. A tube finning machine for mounting extended surface members upon one or more tubes, the machine having a base, carrier means movable relative to the base, drive means for moving the carrier means, and cartridge means for locating a plurality of extended surface members, characterised in that a clamping means is mounted to

- 22 -

the base for clamping a portion of at least one tube in a substantially fixed position relative to the base, and in that the cartridge means is connected to the carrier means so that said plurality of fins can be moved to an axially predetermined position relative to the tube(s).

8. A tube finning machine according to claim 7 in which the cartridge means has a respective support means for each extended surface member.
9. A tube finning machine according to claim 8 in which each support means spans a substantial part of the extended surface member.
10. A tube finning machine according to claim 9 in which the periphery of the extended surface members lie within the periphery of the support means.
11. A tube finning machine according to claim 7 in which at least some of the support means are movable relative to the cartridge.
12. A tube finning machine according to claim 11 in which the support means are biased apart by resilient biasing means.
13. A tube finning machine according to claim 8 in which each support means comprises separable parts.
14. A tube finning machine for mounting extended surface members upon one or more tubes, the machine having a base, carrier means movable relative to the base, drive means for moving the carrier means, and cartridge means for locating a plurality of extended surface members, characterised in that the cartridge means has a respective support means for each extended surface

- 23 -

member, and in that each support means spans a substantial part of the extended surface member.

15. A tube finning machine according to claim 14 in which the periphery of the extended surface members lie within the periphery of the support means.
16. A tube finning machine according to claim 14 in which at least some of the support means are movable relative to the cartridge.
17. A tube finning machine according to claim 16 in which the support means are biased apart by resilient biasing means.
18. A tube finning machine according to claim 14 in which each support means comprises separable parts.
19. A method of mounting extended surface members to one or more tubes using a machine according to claim 2, characterised by the following steps: {i} mounting one or more tubes onto the machine, {ii} mounting a cartridge means loaded with a plurality of extended surface members onto the machine, {iii} actuating the drive means to cause the carrier means to effect relative movement of the cartridge means and tube(s) until the leading extended surface member within the cartridge means reaches a first predetermined position relative to the tube(s), {iv} moving the support means of the leading extended surface member laterally relative to the cartridge means, and {v} actuating the drive means again to cause the carrier means to effect further relative movement of the cartridge means and tube(s) until the next extended surface member within the cartridge means reaches a second predetermined position relative to the tube(s).



1/5

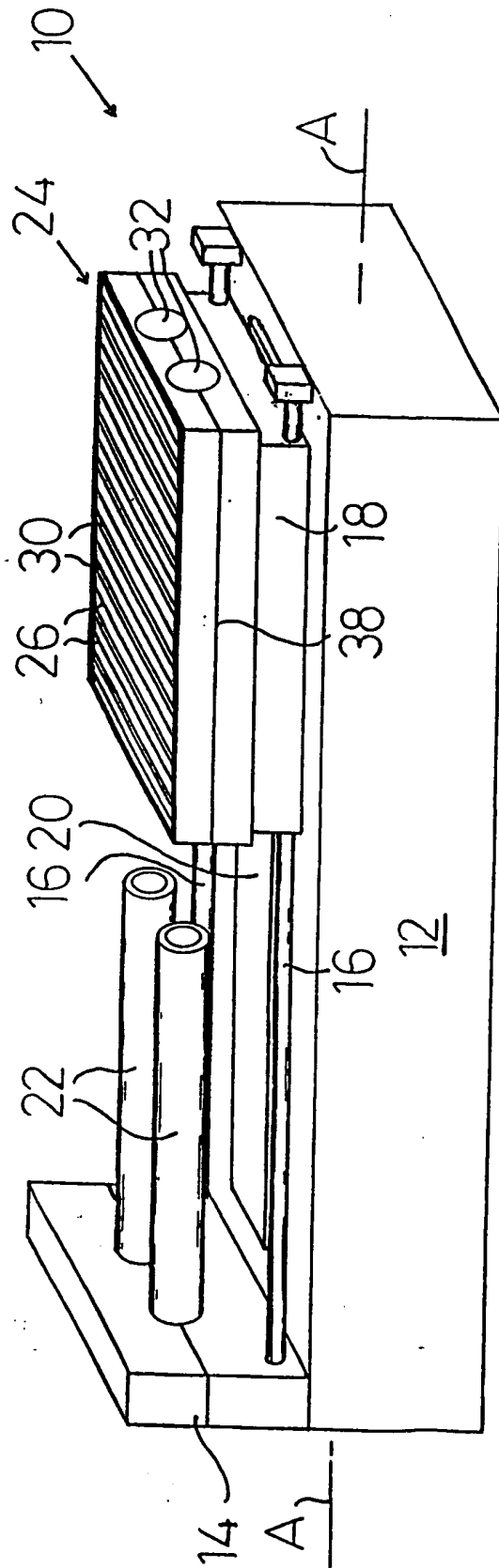
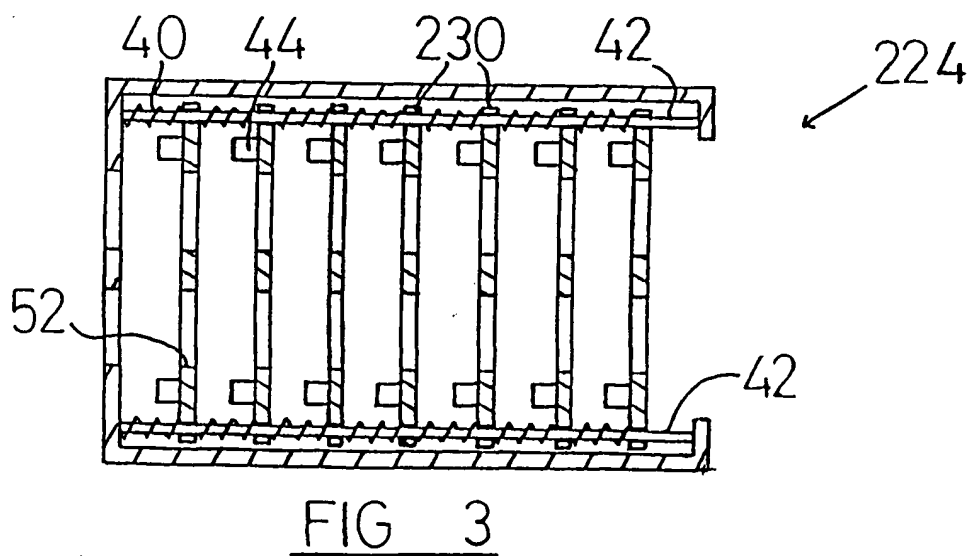
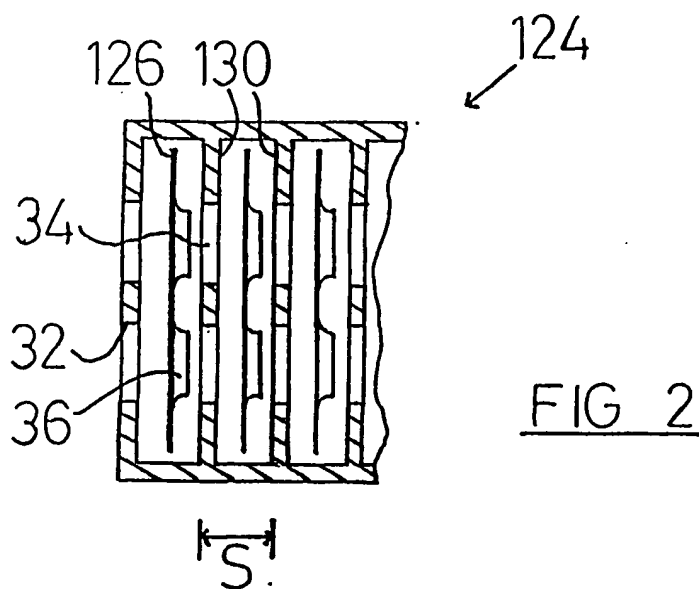
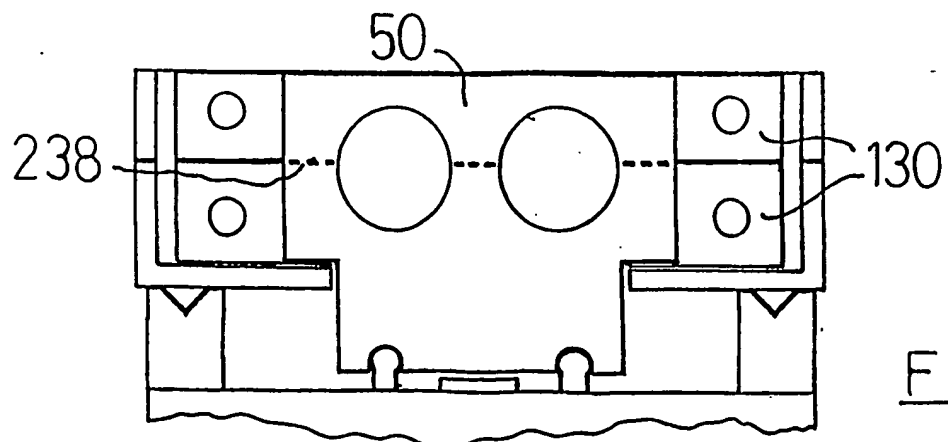
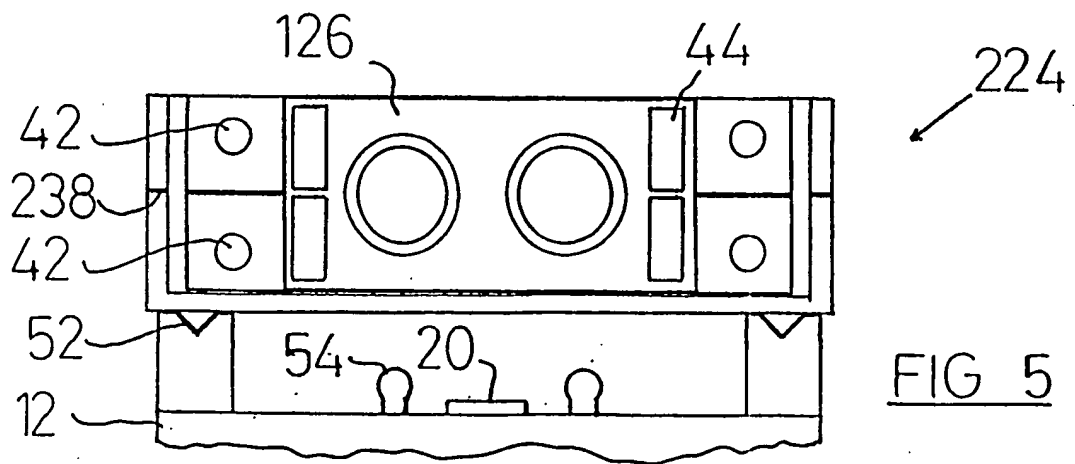
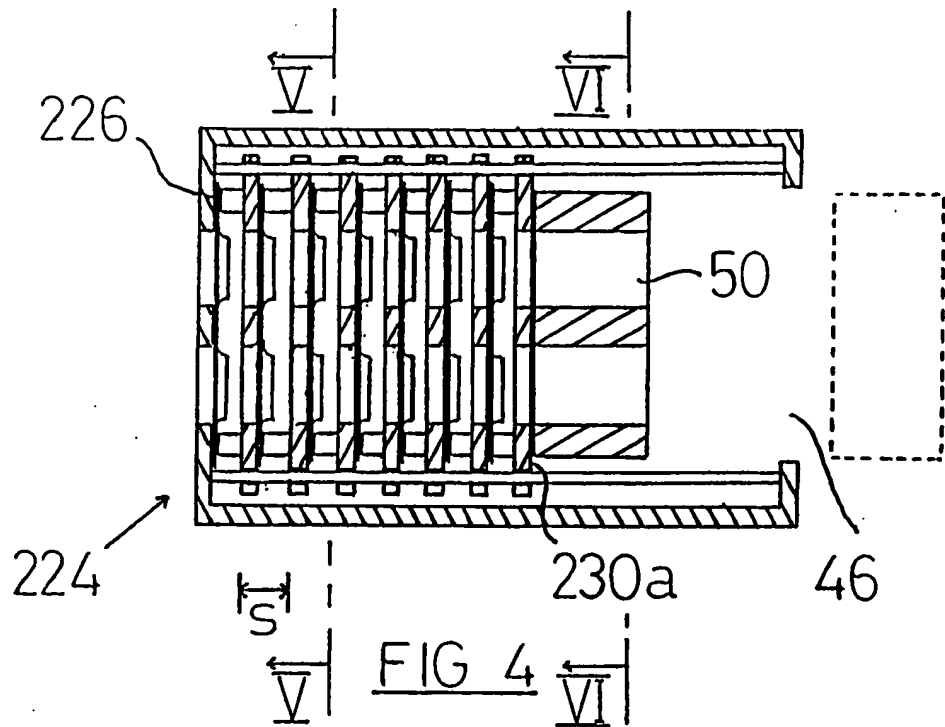


FIG. 1

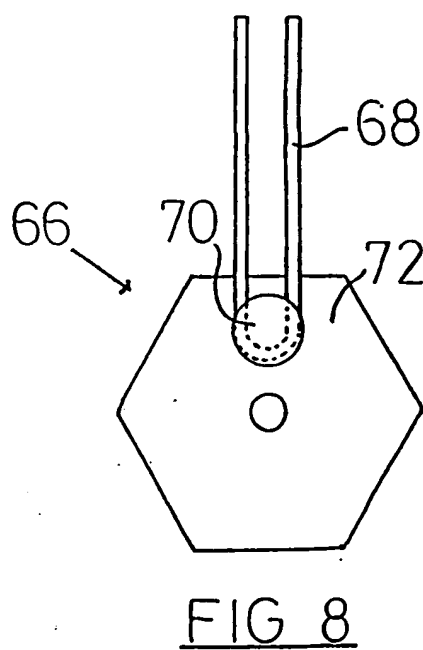
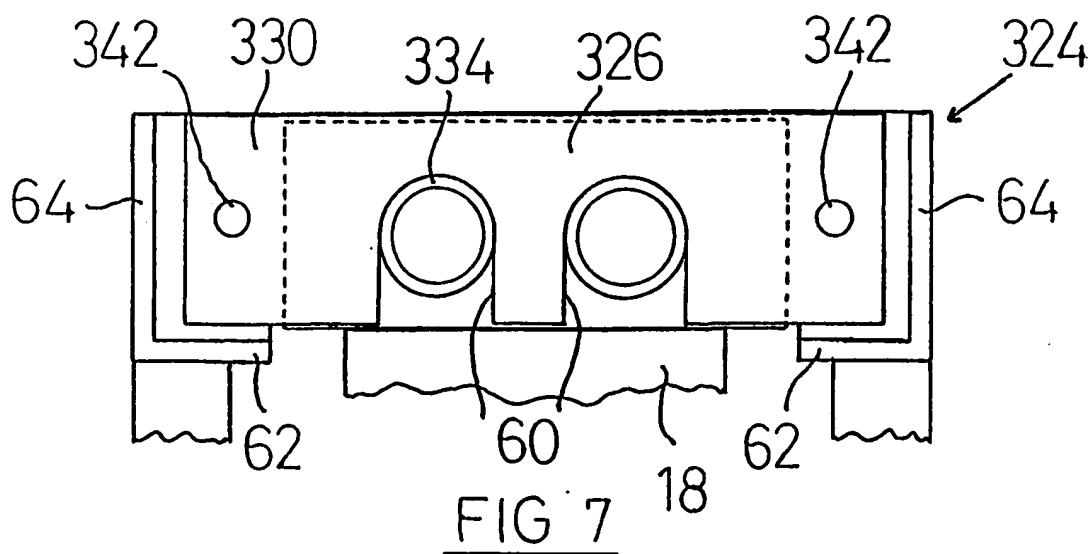
2/5



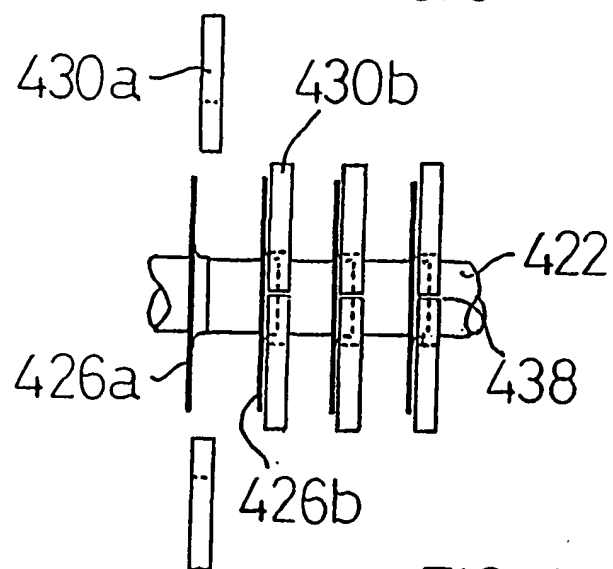
3/5



4/5



5/5

FIG 9

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**